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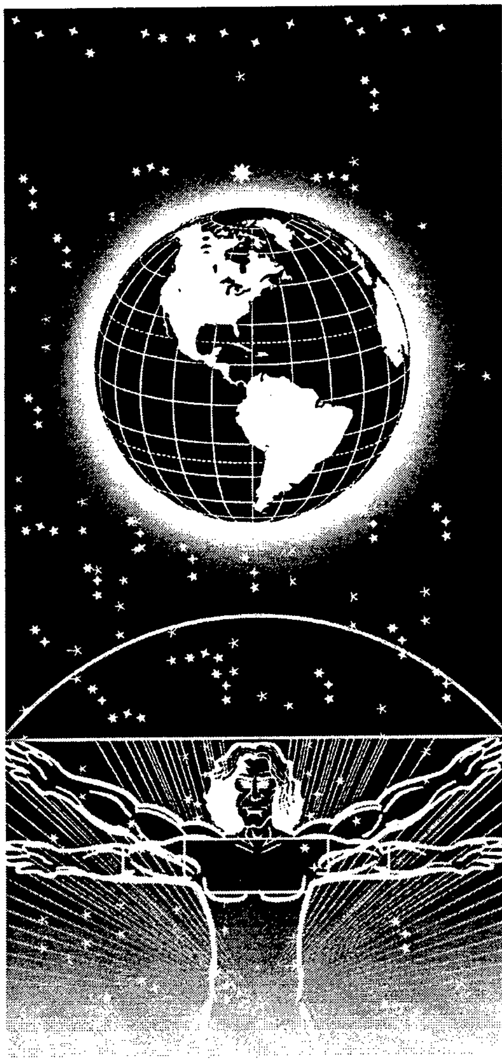

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ABILITY-REQUIREMENT FACTORS UNDERLYING NOMOTHETIC JOB DESCRIPTORS

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13. ABSTRACT (Maximum 200 words)

General nomothetic job descriptors (NJDs) are useful in describing, comparing, and grouping a broad spectrum of jobs. Moreover, NJDs are potentially linkable to measurable human attributes through the "job component" approach under which attribute-requirement weights are derived for a universal set of job components (NJDs or NJD factors). Subsequently, attribute-requirement estimates can be derived for any job that has been rated or scored on the weighted components. This study explored factor structures underlying requirement ratings of the NJDs in three structured job analysis questionnaires on basic abilities as defined in three different attribute-requirement inventories. Six ability-requirement factors were similar across all three data sets: General Physical Ability, Equipment-Control Sensorimotor Ability, Manual Ability, Reasoning and Problem Solving, Numerical Ability, and Visual Perception. A seventh Factor, Verbal Ability, was common to two data sets. The results suggest that little systematic rating variance would be lost by condensing the individual abilities to a more manageable number of factors.

14. SUBJECT TERMS Job Analysis; Occupation Analysis Inventory; Job Ability Requirement Estimation Nomothetic Job Descriptors; Position Analysis Questionnaire Job Evaluation Job Component Approach; Manual For Ability Requirement Scales General Work Inventory; Attribute Requirement Inventory			15. NUMBER OF PAGES 35 16. PRICE CODE
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ABILITY-REQUIREMENT FACTORS FOR GENERAL JOB ELEMENTS

In previous articles, Ballentine, Cunningham, and Wimpee (1992) and Cunningham, Wimpee, and Ballentine (1990) proposed nomothetic job analysis as a useful supplement to the military job-task inventory method (Christal & Weissmuller, 1988). In comparison to job-task inventories, nomothetic job analysis questionnaires contain more general descriptors applicable to wide ranges of jobs. Examples of the more generic or nomothetic job elements can be found in structured job analysis questionnaires such as the Position Analysis Questionnaire (PAQ; McCormick, Jeanneret, & Mecham, 1972), Job Element Inventory (JEI; Cornelius, Hakel, & Sackett, 1979), Occupation Analysis Inventory (OAI; Cunningham, Boese, Neeb, & Pass, 1983), General Work Inventory (GWI; Cunningham et al., 1990), and Common Metric Questionnaire (CMQ; Harvey, 1991). Although some exploratory research has been conducted with the PAQ, JEI, and GWI in military settings, the nomothetic approach has seen limited use in military job analysis to date.

In addition to their advantage in describing, comparing, and grouping a broad spectrum of jobs, nomothetic job descriptors (NJDs) are potentially linkable to measurable human attributes, such as basic abilities and skills, general vocational capabilities, and work-related interests and needs. A proposed means of linking NJDs to human attributes has been termed the "job component" approach (McCormick, 1979), under which (a) a universal set of job components (NJDs or NJD factors) is developed and (b) requirement weights are derived for the components on various human attributes. Subsequently, attribute-requirement estimates can be derived for any job that has been rated or scored on the weighted components. This approach is depicted in Figure 1, which shows a matrix of requirement weights of $\underline{q}$ job components for $\underline{k}$ defined human attributes. Based on this matrix, a job's estimated requirement for attribute 1, for example, could be derived by taking the sum of cross-products of the job's scores on the $\underline{q}$ components times the components' corresponding weights for attribute 1 (or by some alternative algorithm for combining job scores and requirement weights; cf. Sparrow, 1989).

Human Attributes

		1	2	3	.	.	k
	1	W_{11}	W_{12}	W_{13}	.	.	W_{1k}
	2	W_{21}	W_{22}	W_{23}	.	.	W_{2k}
Job	3	W_{31}	W_{32}	W_{33}	.	.	W_{3k}
Components	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	.	.	.	.	.	.	.
	q	W_{q1}	W_{q2}	W_{q3}	.	.	W_{qk}

Figure 1. Requirement weights of q job components on k human attributes.

Although applicable to job-task inventories, this method is considerably more expensive in that context because of the necessity of developing a weight matrix specific to every inventory. The job component approach also promises some potential advantages over another alternative, direct global ratings of a job's attribute requirements. Once a weight matrix as depicted in Figure 1 is established, a job's attribute requirements can be estimated from ratings by any knowledgeable respondent (e.g., literate incumbents or line supervisors) on relatively concrete NJDs representing observable work activities and conditions (Cunningham et al., 1990). In comparison, direct job ratings on the more abstract attribute definitions might be too demanding for some otherwise qualified NJD raters. Moreover, the job component approach provides a basis for explaining why a job requires particular attributes (i.e., because it involves specific NJDs with those requirements), as opposed to relying entirely on the expert judgment argument inherent in a job's direct attribute requirement ratings. Based on the Spearman-Brown principle, job component estimates of ability requirements should also show higher reliabilities per

respondent, because they are derived from the respondent's ratings on a number of weighted NJDs, rather than from single global job ratings on each attribute requirement.

There are two basic ways of deriving attribute-requirement weights for job components: (a) attribute-requirement ratings of the components by experts and (b) policy capturing (Christal, 1968), involving regression analysis in which jobs' component scores serve as predictor ($\underline{x}$) variables and some external measure of the jobs' requirements for a particular attribute serves as the criterion ($\underline{y}$) variable. Under the policy-capturing method, the derived regression coefficients subsequently serve as the components' attribute-requirement weights. Two criterion variables have been used with some success in policy capturing ability requirements: (a) mean test scores for representative job incumbent samples and (b) test validity coefficients for jobs (McCormick et al., 1972; Cunningham et al., 1983). Neither of these two criteria, however, have shown much differentiation among abilities. Thus two factors (Cognitive and Motor) accounted for 80% of the variance in incumbent mean scores for 434 jobs on eight U. S. Employment Service General Aptitude Test Battery tests, and three factors (Cognitive, Motor, and Perceptual) accounted for 77% of the variance in the validity coefficients for those tests (Cunningham & Scott, 1988; Hunter, 1983). From a practical standpoint, moreover, mean incumbent test scores and validity coefficients are difficult and expensive to obtain for representative samples of jobs. Probably for that practical reason, the first of the aforementioned methods (expert ratings) is the one most frequently used to derive job components' ability weights (Peterson & Bownas, 1982).

The job component approach has been applied with at least four general nomothetic job analysis questionnaires: the Worker Activity Profile (McCormick, Cunningham, & Thornton, 1967); the PAQ (McCormick et al., 1972; McCormick, DeNisi, & Shaw, 1979; McCormick & Jeanneret, 1988); the OAI (Cunningham et al., 1983; Cunningham, 1988; Cunningham & Scott, 1988); and the GWI (Cunningham et al., 1990). Except for analyses of PAQ data, however, relationships among ability-requirement estimates for generic job elements have received little attention (Jeanneret & McCormick, 1969; Marquardt & McCormick, 1973). Accordingly, the study reported here explored the factor structures underlying average ability-requirement rating matrices (as depicted in Figure 1) derived for three of the forenamed instruments: the PAQ, OAI,

and GWI. Cross-instrument comparisons were carried out among the resultant ability-requirement factors in an effort to establish their convergent validity. The study was not designed to assess the instruments involved, but rather to explore the dimensionality and cross-system commonality of NJD ability-requirement ratings.

METHOD

Instruments

Job analysis questionnaires. As mentioned, the present study included three nomothetic job analysis questionnaires (the PAQ, OAI, and GWI). The PAQ, the most widely used and researched structured job analysis questionnaire, contains 194 mostly "worker-oriented" elements describing basic human activities, as contrasted with "job-oriented" elements which describe the technological content and outcomes of work (cf. McCormick & Jeanneret, 1988). The OAI is a taxonomic research tool containing a mixture of 617 worker- and job-oriented elements, and the GWI is a 268-element questionnaire derived partly from selected OAI factors and modified or merged OAI elements. In addition to being considerably shorter than the OAI, the GWI is written at a less technical level and is intended for use by any literate respondent who is familiar with the job to be analyzed. GWI position ratings have been performed by over 2,100 incumbents in 164 Air Force enlisted specialties (Cunningham et al., 1990). Substantial differences between the GWI and OAI elements, plus the use of different ability-requirement inventories and raters with these two instruments, warranted including them both in this study.

Ability-requirement inventories. Three ability-requirement instruments were combined with the forenamed job analysis questionnaires, as follows: (a) a specially developed set of ability-requirement definitions that were applied to the PAQ job elements (Mecham & McCormick, 1969; Marquardt & McCormick, 1972); (b) the Attribute Requirement Inventory (ARI), applied to the OAI elements (Neeb, Cunningham, & Pass, 1971; Pass & Cunningham, 1975); and (c) Fleishman's Manual for Ability Requirement Scales (MARS), applied to the GWI elements (Fleishman, 1975, 1990; Fleishman & Quaintance, 1984; Fleishman & Mumford, 1988). The MARS (now titled the Fleishman Job Analysis Survey; Fleishman & Reilly, 1992) was selected for this study because it is the most rigorously developed and widely used of the

ability-requirement inventories (Landy, 1988); the ARI and PAQ attribute scales were used in two previous studies that provided comparative data. Table 1 lists the titles of the basic abilities defined in the three instruments. Ability titles whose definitions are comparable across instruments appear on the same line in the table. The PAQ, ARI, and MARS sets contained totals of 49, 38, and 54 basic ability definitions, respectively. (Nine of the original 65 MARS ability items were too content or knowledge specific for use in the present study.) A substantial number of these definitions corresponded to cognitive factors identified by French, Ekstrom, and Price (1963) and psychomotor factors derived by Fleishman (1967).

Table 1. Titles and Reliabilities of Ability Requirements in Three Data Sets: MARS-GWI, ARI-OAI, and PAQ

	MARS-GWI		ARI-OAI		PAQ
1.	Fluency of Ideas (.91)	1.	Ideational Fluency (.91)	1.	Ideational Fluency (.90)
2.	Originality (.89)	2.	Originality (.96)	2.	Originality (.86)
3.	Problem Sensitivity (.62)	3.	Sensitivity to Problems (.88)	3.	Problem Sensitivity (.88)
4.	Number Facility (.77)	4.	Number Facility (.96)	4.	Numerical Computation (.92)
5.	Spatial Orientation (.82)	5.	Spatial Orientation (.90)	5.	Spatial Orientation (.88)
6.	Visualization (.62)	6.	Visualization (.94)	6.	Spatial Visualization (.90)
7.	Multilimb Coordination (.90)	7.	Multilimb Coordination (.92)	7.	Kinesthesis (.96)
8.	Rate Control (.81)	8.	Control Precision[a] (.95)	8.	Rate Control (.87)
9.	Reaction Time (.83)	9.	Reaction Time (.92)	9.	Simple Reaction Time (.80)
10.	Arm-Hand	10.	Arm-Hand	10.	Arm-Hand

Steadiness (.92)	Steadiness (.93)	Steadiness (.88)
11. Manual Dexterity (.90)	11. Manual Dexterity (.96)	11. Manual Dexterity (.94)
12. Finger Dexterity (.88)	12. Finger Dexterity (.90)	12. Finger Dexterity (.93)

Table 1 (continued)

MARS-GWI	ARI-OAI	PAQ
13. Static Strength (.91)	13. Static Strength (.90)	13. Static Strength (.95)
14. Explosive Strength (.83)	14. Explosive Strength (.91)	14. Explosive Strength (.85)
15. Dynamic Strength (.84)	15. Dynamic Strength (.89)	15. Dynamic Strength (.94)
16. Gross Body Equilibrium (.91)	16. Body Equilibrium (.85)	16. Body Orientation (.85)
17. Stamina (.88)	17. Stamina (.89)	17. Stamina (.90)
18. Near Vision (.88)	18. Near Visual Acuity (.93)	18. Near Visual Acuity (.91)
19. Far Vision (.92)	19. Far Visual Acuity (.93)	19. Far Visual Acuity (.92)
20. Depth Perception (.87)	20. Depth Perception (.92)	20. Depth Perception (.93)
21. Visual Color Discrimination (.80)	21. Color Discrimination (.93)	21. Color Discrimination (.90)
22. General Hearing (.86)	22. Auditory Acuity (.92)	22. Auditory Acuity (.93)
23. Oral Comprehension (.91)	23. Verbal Comprehension (.97)	23. Verbal Comprehension (.96)
24. Written Comprehension[b] (.90)	....	....
25. Oral Expression (.96)	24. Expressional Fluency (.97)	24. Word Fluency (.94)
26. Written Expression[b] (.95)	....	25. Oral Communication[b] (.96)

27. Memorization (.82)	25. Memory (.84)	26. Long Term Memory (.90)
....	....	27. Short Term Memory[b] (.86)

Table 1 (continued)

MARS-GWI	ARI-OAI	PAQ
28. Deductive Reasoning (.68)	26. Deductive Reasoning (.93)	28. Convergent Thinking (.87)
29. Inductive Reasoning[b] (.79)	27. Inductive Reasoning[b] (.90)	....
30. Grammar (.93)	28. Grammar (.97)	....
31. Spelling (.92)	29. Spelling (.97)	....
32. Perceptual Speed (.57)	30. Perceptual Speed (.94)	....
33. Mathematical Reasoning (.84)	....	29. Arithmetic Reasoning (.90)
34. Selective Attention (.62)	....	30. Selective Attention (.91)
35. Time Sharing (.33)	....	31. Time Sharing (.90)
36. Control Precision (.71)	....	32. Arm-Hand Positioning (.95)
37. Speed of Limb Movement (.81)	....	33. Speed of Limb Movement (.95)
....	31. Aesthetic Judgment (.98)	34. Aesthetic Judgment (.82)
....	32. Form Perception (.93)	35. Visual Form Perception (.94)
....	33. Eye-Hand Coordination (.95)	36. Eye-Hand Coordination (.94)

....	34. Tactual Discrimination (.89)	37. Tactual Acuity (.94)
....	35. Closure (.88)	38. Closure (.87)
38. Information Ordering (.87)	....	....
39. Category Flexibility (.79)	....	....

Table 1 (continued)

MARS-GWI	ARI-OAI	PAQ
40. Response Orientation (.63)	....	....
41. Wrist-Finger Speed (.72)	....	....
42. Trunk Strength (.80)	....	....
43. Extent Flexibility (.84)	....	....
44. Dynamic Flexibility (.86)	....	....
45. Gross Body Coordination (.88)	....	....
46. Night Vision (.89)	....	....
47. Peripheral Vision (.86)	....	....
48. Glare Sensitivity (.79)	....	....
49. Auditory Attention (.84)	....	....
50. Sound Localization (.83)	....	....
51. Speech Hearing (.93)	....	....
52. Speech Clarity (.93)	....	....
53. Speed of Closure[c] (.58)	....	....
54. Flexibility of Closure[c] (.65)		....
....		
....	36. Spatial Scanning (.84)	....
....	37. Social Intelligence (.97)	....

....	38. Musical Aptitude (.97)	....
....	....	39. Movement Detection (.88)
....	....	40. Olfactory Acuity (.92)
....	....	41. Gustatory Acuity (.87)
....	....	42. Divergent Thinking (.91)
....	....	43. Intelligence (.94)

Table 1 (continued)

MARS-GWI	ARI-OAI	PAQ
....	....	44. Continuous Muscle Control (.93)
....	....	45. Rate of Arm Movement (.93)
....	....	46. Eye-Hand-Foot Coordination (.92)
....	....	47. Response Integration (.91)
....	....	48. Mechanical Ability (.84)
....	....	49. Perceptual Speed[c] (.88)

Note. The following scales were used to rate the ability requirements of the job elements:

MARS-GWI	ARI-OAI	PAQ
0 = Unimportant	0 = Does not apply	0 = Attribute is of no relevance to job element
1 = Somewhat Important	1 = Very limited relevance	1 = Very limited or nominal relevance
2 = Moderately Important	2 = Limited relevance	2 = Limited relevance
3 = Important	3 = Moderate relevance	3 = Moderate relevance
4 = Very Important	4 = Substantial relevance	4 = Substantial or considerable relevance
	5 = Very high relevance	5 = Extreme or extensive relevance

[a]The ARI definition of Control Precision was judged to correspond with the definitions of Rate Control in the other two data sets.
[b]This ability was merged with the one immediately above it to form a better match with broader definitions in one or both of the other data sets.
[c]Because of a judged lack of correspondence, this definition was not matched with definitions under the same (or similar) title in the other two data sets.

Procedures

Each element in the three job analysis questionnaires was rated on its requirement for each basic ability in the set that was applied to its questionnaire (see Table 1). The PAQ and ARI-OAI data were available from previous research, whereas the MARS-GWI data were collected specifically for this study. The PAQ and ARI-OAI ability-requirement ratings were performed with 6-point "Degree of Relevance" (of the ability to the element) scales, and the MARS-GWI ratings were performed with a specially constructed "Importance" (of the ability to the element) scale. The original behaviorally anchored MARS rating scales, involving level of ability required, were not applied to the GWI job elements in this study because of their possible confounding with level ranges within the elements (i.e., because of the problem inherent in judging level of ability required by an element that can involve different levels of difficulty). Instead, the MARS scales were included as part of the ability definitions that were rated on the Importance scale. The rating scales used in this study are shown in the note for Table 1. For each ability definition, the PAQ ratings were carried out by 8-11 industrial psychologists (Marquardt & McCormick, 1973); the ARI-OAI ratings, by 19-20 psychology graduate students; and the MARS-GWI ratings, by 6-14 psychologists, human resource managers, Air Force occupational analysts, and/or psychology graduate students.

A job element's requirement weight for a particular ability was derived by computing its average over the judges' ratings. This produced a profile of average requirement ratings for each element on all abilities, which in combination with the average profiles for the other elements in its job analysis questionnaire, produced an element-by-ability matrix of average ratings as depicted in Figure 1. Matrices of the order 182-by-49, 545-by-38, and 217-by-49 were compiled

from the PAQ, ARI-OAI, and MARS-GWI ratings, respectively. (In all three instruments, some of the original elements were omitted as inappropriate for ability-requirement ratings.) The entries in the ARI-OAI and MARS-GWI matrices were mean ratings, whereas those in the PAQ matrix were median ratings. The reliability of each ability column in each matrix was estimated by a repeated measures analysis-of-variance procedure, in which judges represented categories of a factor, the job elements were cases on which repeated measures were taken, and the ability-requirement ratings were the measures (Winer, 1971). This analysis produced an estimated reliability for the elements' mean ratings on each ability; that is, an estimated correlation between an abilities mean rating vector and a corresponding vector obtained from a new sample of comparable judges. The resultant reliability coefficients for the PAQ ranged from .80 to .96, with a mean value of .90 (median=.91; Marquardt & McCormick, 1973); those for the ARI-OAI, from .84 to .98, with a mean value of .92 (median=.92; Pass & Cunningham, 1975); and those for the MARS-GWI, from .33 to .96, with a mean value of .81 (median=.84).

Table 1 presents the reliability coefficients for the individual abilities. With only one exception (the value of .33 for Time Sharing in the MARS-GWI column), all of these reliability values are more than sufficient for research purposes. It should be noted that the MARS-GWI reliabilities are based on (a) a specially constructed Importance scale rather than the behaviorally anchored MARS scales and (b) smaller and more heterogeneous rater sets than recommended; . The MARS-GWI scale contained fewer points than the original MARS scales (or the ARI-OAI and PAQ scales), and the points were marked only with adjective descriptors. Hence, the MARS-GWI reliabilities reported here underestimate those from more typical ratings of tasks or work activities on the regular MARS scales (Fleishman & Mumford, 1988). It should also be mentioned that the coefficients in Table 1 estimate the reliabilities of ,mean ratings, whereas the entries in the PAQ ability-requirement matrix were medians. nevertheless these reliabilities can be accepted as reasonable stability estimates for the PAQ median ability vectors as well, because the median vectors correlated very highly (.97) with corresponding mean vectors (Marquardt & McCormick, 1973).

Analyses and Results

A separate factor analysis was performed on each of the three data sets. The ability-requirement columns were intercorrelated in each of the previously described element-by-ability matrices, and the resultant correlation matrix was subjected to principal axes analysis using squared multiple correlations as communality estimates. The appropriate number of factors, as initially estimated by examination of the eigenvalue pattern (Cattell, 1966), was then rotated to a normalized varimax solution (Kaiser, 1958; Sarle & Sall, 1982). In each data set, two or three rotation solutions (involving different numbers of rotated factors) were computed, and the most meaningful result was retained. In a factor replication analysis, the judges contributing to the MARS-GWI data set were divided into two comparable subsamples, and the subsample rating data were subjected to independent factor analyses. Each factor from the total sample was then matched with its closest counterpart in each of the two subsamples, and the coefficient of congruence (cosine between rotated factor loading vectors) was computed between the two corresponding subsample factors as a stability estimate (Gorsuch, 1974). Because only the average ability-requirement rating matrices were available for the PAQ and ARI-OAI data sets, replication analyses were not performed on their factors. Table 2 summarizes the results by presenting the title, percentage of variance accounted for, and salient abilities and loadings for each of the rotated ability-requirement factors. The salient abilities are designated in Table 2 by numbers corresponding to their title locations in Table 1. Congruence coefficients are presented for the MARS-GWI factors. The MARS-GWI, ARI-OAI, and PAQ factor solutions accounted for .86, .64, and .84 of their systems' total variance, respectively.

Table 2 Ability-Requirement Factors: Salient Abilities and Their Loadings, Percentages of Variance Explained, and Coefficients of Congruence

Analysis and Factor Title[a]	Salient Abilities and Their Loadings[b]
MARS-GWI Analysis	

1. General Physical Ability (19.73, .98)	42(90), 17(90), 45(90), 15(88), 44(87), 13(83), 16(82), 43(82), 14(81), 37(75), 7(74), 11(40)
2. Equipment-Control Sensorimotor Ability (13.70, .97)	48(89), 47(88), 19(86), 46(85), 5(80), 20(73), 9(72), 8(68), 40(68)
3. Verbal Ability (12.32, .92)	24(86), 25(80), 1(80), 30(78), 52(75), 2(75), 31(72), 39(59), 29(52), 38(47), 23(41)

Table 2 (continued)

Analysis and Factor Title[a]	Salient Abilities and Their Loadings[b]
4. Manual Ability (10.10, .95)	12(88), 10(82), 11(81), 41(80), 36(78), 18(43), 37(43)
5. Reasoning and Problem Solving (8.23, .87)	3(82), 35(76), 28(72), 34(63), 29(61), 27(51), 23(42)
6. Auditory Ability (7.99, .96)	22(91), 49(90), 50(85), 51(71), 52(45), 23(42)
7. Numerical Ability (5.17, .92)	33(79), 4(78), 38(61)
8. Visual Perception (3.17, .83)	6(73), 21(68)
9. Written Comprehension (2.66)[c]	24(68), 18(48)
10. Closure (2.62)[c]	54(60), 53(57), 32(41)
<u>ARI-OAI Analysis</u>	
1. Manual Ability (10.98)	10(85), 33(81), 12(78), 11(78), 34(66), 8(48), 7(45), 18(41)
2. Verbal Ability (8.68)	28(92), 29(83), 23(77), 24(74), 1(40)
3. General Physical Ability (8.42)	15(86), 13(84), 14(77), 17(77)
4. Equipment-Control Sensorimotor Ability	9(72), 19(69), 8(65), 5(65), 7(62), 20(61)

	(8.11)	
5.	Reasoning and Problem Solving (7.81)	27(75), 2(71), 1(71), 26(70), 3(59)
6.	Visual Perception (7.17)	32(80), 6(73), 35(65), 36(60)
7.	Numerical Ability (4.23)	4(60), 30(51), 25(46), 18(44)
8.	Auditory Ability (3.48)	22(62), 37(59)
9.	Aesthetic Ability (3.32)	31(74), 38(54), 21(42)
10.	Body Equilibrium (1.88)	16(42)

Table 2 (continued)

	Analysis and Factor Title[a]	Salient Abilities and Their Loadings[b]
<u>PAQ Analysis</u>		
1.	General Physical Ability (27.24)	15(94), 13(93), 33(90), 14(89), 7(88), 45(87), 44(85), 46(82), 17(81), 47(81), 16(80), 32(77), 36(75), 10(71), 37(70), 11(67), 8(56), 12(53), 5(51), 9(46), 39(41)
2.	Reasoning & Problem Solving (21.78)	43(92), 31(89), 26(87), 3(87), 27(84), 23(84), 28(81), 25(80), 24(79), 1(79), 42(76), 30(76), 2(76), 29(63), 38(59), 22(55), 4(44)
3.	Visual Perception (17.15)	35(91), 6(88), 21(83), 19(82), 20(81), 49(79), 18(76), 5(67), 48(62), 39(61), 38(59), 34(48), 8(42)
4.	Manual Ability (5.32)	12(72), 11(61), 10(57), 32(53), 36(45), 37(43)
5.	Equipment-Control Sensorimotor Ability (3.76)	9(62), 8(51), 39(51), 22(45)

6.	Taste-related ability (3.16)	41(81), 40(79)
7.	Numerical Ability (3.04)	4(76), 29(60)
8.	Mechanical Ability (2.23)	48(42)

[a]The two values in parentheses following the factor title are the factor's percentage of total variance accounted for and coefficient of congruence, respectively. Congruence coefficients were computed in the MARS-GWI analysis only.
[b]Each salient ability is represented by its number, followed in parentheses by its loading (with the decimal omitted). The ability's title can be found in Table 1 under its appropriate number.
[c]No coefficient of congruence was computed because matching subsample factors failed to emerge.

For the purpose of cross-system comparison, a second group of factor analyses was conducted including only abilities whose definitions were judged to be comparable between data sets, or systems. The titles of comparable abilities appear on the same lines in Table 1. As noted in Table 1, three pairs of MARS-GWI abilities, one pair of ARI-OAI abilities, and two pairs of PAQ abilities were combined when matched with more broadly defined abilities in other systems. For example, Oral Comprehension and Written Comprehension in the MARS-GWI set were combined to match Verbal Comprehension in the ARI-OAI and PAQ systems. Thirty abilities were judged comparable between the MARS-GWI and ARI-OAI systems; 31 abilities, between the MARS-GWI and PAQ systems; and 31 abilities, between the ARI-OAI and PAQ systems. Preparatory to comparison, the previously described factor analytic procedure was applied twice to each system, including only the abilities in that system that were comparable to abilities in each of the other two systems. In the MARS-GWI system, for example, one factor analysis was performed on the 30 abilities in common with the ARI-OAI system, and a second on the 31 abilities in common with the PAQ system. Similarly, factor analyses of 30 and 31 common abilities were carried out in the ARI-OAI system, and two analyses of 31 abilities each in the PAQ system. Cross-system congruence coefficients were then computed between rotated factors. In this case a congruence coefficient was the cosine between two rotated factors with loadings on comparable abilities. Table 3 presents congruence matrices for the three cross-systemcomparisons.

Table 3 Cross-System Congruence Coefficients Between Factors from Matched Ability Sets[a,b,c]

		PAQ						MARS-GWI						
		GP	EC	Mn	RP	Nm	VP	GP	EC	Mn	RP	Nm	VP	Vb
	GP	<u>87</u>	20	48	-35	-17	10	<u>89</u>	32	44	-33	-26	-02	-41
	EC	55 (38)	<u>74</u>	45	-24	-19	56	48 (40)	<u>94</u>	39	-20	-19	11	-39
	Mn	58 (53)	37 (41)	<u>93</u>	-37	-04	35	40 (42)	36 (38)	<u>95</u>	-28	04	17	-38
	RP	-29 (-32)	-26 (-25)	-29 (-33)	<u>84</u>	15	-09	-31 (-32)	-30 (-25)	-33 (-30)	<u>86</u>	-05	10	74
ARI-OAI	Nm	-36 (-26)	-14 (-16)	-17 (-10)	41 (28)	<u>79</u>	-10	-41 (-34)	-30 (-24)	-21 (-08)	43 (19)	<u>84</u>	08	18
	VP	-02 (04)	01 (28)	18 (26)	03 (-03)	36 (13)	<u>79</u>	-02 (-02)	06 (08)	17 (17)	-19 (-04)	17 (12)	<u>90</u>	-23
	Vb	-34	20	-34	77	02	-40	-44 (-42)	-34 (-36)	-38 (-38)	44 (59)	29 (24)	-24 (-24)	<u>85</u>
	At	-09	-26	02	03	-18	48	--[d]	--[d]	--[d]	--[d]	--[d]	--[d]	
	BE	51	15	20	-25	-26	-12	51	25	08	-27	-22	-14	-11

Table 3 (concluded)

		PAQ					
		GP	EC	Mn	RP	Nm	VP
	GP	95	41	51	-41	-37	30
	EC	60 (50)	77	40	-14	-25	72
	Mn	65 (58)	47 (44)	94	-30	-12	47
MARS-GWI	RP	-21 (-31)	16 (01)	-15 (-22)	91	34	05
	Nm	-43 (-40)	-28 (-26)	-16 (-14)	44 (39)	94	-03
	VP	-03 (14)	-15 (28)	24 (36)	-07 (-01)	25 (11)	66
	Vb	-43	-50	-39	76	21	-41

[a]GP=General Physical Ability; EC=Equipment-Control Sensorimotor Ability; Mn=Manual Ability; RP=Reasoning & Problem Solving;
Vb=Verbal Ability; Nm=Numerical Ability; VP=Visual Perception; As=Aesthetic Ability; BE=Body Equilibrium.
[b]The decimals are omitted from the coefficients of congruence, whose values can range from +1.00 to -1.00.
[c]Each value in parentheses is the mean of the entry immediately above it and that entry's correspondent above the main diagonal.

[d]There was no cross-instrument pairing of this factor

The underlined, main-diagonal values in Table 3 are coefficients between factors judged to be comparable, and the remaining values are coefficients between factors that, though in some instances possibly related, were not judged as directly comparable. Each value in parentheses is the mean of the entry immediately above it and that entry's correspondent above the main diagonal In the matrix of coefficients between the PAQ and ARI-OAI factors, for example, the first parenthesized value in row Mn (.53, at the intersection of row Mn and column GP) is the mean of .58 and its corresponding value, .48 (at the intersection of row GP and column Mn). In each of the three matrices, a line appears below the last row that has a corresponding column representing the same construct; the rows above that line form a square convergent-discriminant matrix, whereas the rows below the line represent factors from the row data set that did not emerge from the column data set. The values in parentheses form a mean discriminant triangle. Table 4 presents a matrix of mean values of corresponding entries from the matrices in Table 3. The Verbal Ability factor has been relocated in Table 4 to facilitate interpretation.

With one exception in Table 3 (Visual Perception, in the comparison of the MARS-GWI with the PAQ), the underlined (convergent) values in Tables 3 and 4 are the largest in their respective rows and columns. A Monte Carlo procedure for multitrait-multimethod analysis (Knoeller & Iwaniszek, 1990) was applied separately to each of the four square matrices in the two tables to determine whether the mean main-diagonal (convergent) value was significantly larger than the mean off-diagonal (discriminant) value (cf. Campbell & Fiske, 1959). In all four matrices, the probability that the observed difference between the two means occurred randomly was less than .002. Finally, the four mean discriminant triangles in Tables 3 and 4 were cluster analyzed to explore broader ability-requirement groupings. In these analyses, the entries in each discriminant triangle were converted to dissimilarity indices by subtracting them from 1.00, and the transformed triangles were subjected to hierarchical cluster analysis (Sarle, 1982; Ward & Hook, 1963). The cluster solution presented in Table 5 was judged to be the most meaningful result. This solution included two groupings and two isolates, titled as follows: General Sensorimotor Ability, General Cognitive Ability, Numerical Ability, and Visual Perception. All of the analyses produced the same solution, with the exception that the two six-factor triangles

Table 4. Mean Cross-System Congruence Coefficients Between Factors from Matched Ability Sets[a,b,c]

	GP	EC	Mn	RP	Vb	Nm	VP
GP	90	31	48	-36	-41	-27	13
EC	54 (43)	82	41	-19	-39	-21	46
Mn	54 (51)	40 (41)	94	-32	-38	-04	33
RP	-27 (-32)	-13 (-16)	-29 (-30)	87	74	15	02
Vb	-40 (-40)	-21 (-30)	-37 (-37)	66 (70)	85	18	-23
Nm	-40 (-33)	-24 (-22)	-18 (-11)	43 (29)	17 (18)	86	-02
VP	-02 (05)	-03 (22)	20 (26)	-08 (-03)	-35 (-29)	26 (12)	78
As	-09	-26	02	03	---[d]	-18	48
BE	51	20	14	-26	-11	-24	-13

[a]GP=General Physical Ability; EC=Equipment-Control Sensorimotor Ability; Mn=Manual Ability; RP=Reasoning & Problem Solving; Vb=Verbal Ability; Nm=Numerical Ability; VP=Visual Perception; As=Aesthetic Ability; BE=Body Equilibrium.

[b]The decimals are omitted from the coefficients of congruence, whose values can range from +1.00 to -1.00.

[c]Each value in parentheses is the mean of the entry immediately above it and that entry's correspondent above the main diagonal.

[d]There was no cross-system pairing of these two factors.

did not contain a Verbal Ability factor (see footnote c Table 5). The two isolates, Numerical Ability and Visual Perception, eventually joined the General Cognitive and General Sensorimotor clusters, respectively, in the hierarchical structure; but their congruence coefficients with other cluster members were judged as too small to justify merger.

Table 5. Clusters from the Discriminant Congruence Coefficient Triangles

	Cluster Assignments [a, b]			
Ability-Requirement Factor Titles	C1	C2	C3	C4
General Physical Ability	X			
Equipment-Control Sensorimotor Ability	X			
Manual Ability	X			
Reasoning and Problem Solving		X		
Verbal Ability		X[c]		
Numerical Ability			X	
Visual Perception				X

[a]The column headings represent two clusters and two isolates, as follows: C1= General Sensorimotor Ability; C2=General Cognitive Ability; C3=Numerical Ability; C4=Visual Perception.
[b]"X" indicates assignment of an ability-requirement factor to a cluster.
[c]A Verbal Ability factor was assigned to this cluster only in the analyses of two discriminant triangles: the mean triangle and the triangle between the ARI-OAI and the MARS-GWI. Verbal Ability did not emerge in the factor analyses of abilities common to the other two pairings (PAQ with ARI-OAI and with MARS-GWI); cluster analyses of these pairings' discriminant triangles classified the Reasoning and Problem Solving factor as an isolate.

Discussion

Ability ratings of tasks, task composites, and NJDs are reported rather frequently in the literature; but to our knowledge, only the PAQ research has heretofore explored the factor structure of such ratings (Jeanneret & McCormick, 1969; Marquardt & McCormick, 1973), and we are aware of no previous cross-system comparisons.

The factor structures summarized in Table 2 are meaningful within their respective systems and comparable across systems. The PAQ factors are near replications of the principal components derived by Marquardt and McCormick (1973) from the same data set, with the exception that because they rotated seven instead of eight factors, they did not obtain a separate

Mechanical Ability factor (factor 8 in Table 2). On examination, there appear to be eight similar factors between the MARS-GWI and ARI-OAI systems and six similar factors between the PAQ and each of the other two systems. Moreover, the eight MARS-GWI factors with counterparts in the other two systems showed the best within-system replication (between subsamples). As shown in Table 2, eight of those factors had congruence coefficients $\geq .83$, six of which $\geq .92$; the two MARS-GWI factors without cross-system counterparts, on the other hand, did not replicate. As noted, congruence coefficients were not computed for the ARI-OAI and PAQ factors, because only their average ability-requirement rating matrices were available for this study. It seems likely, however, that their factor structures are more stable than that of the MARS-GWI, because their data involved larger, more homogeneous groups of raters and produced higher interrater reliabilities (as shown in Table 1).

The judged factoral comparabilities across systems appeared to warrant an effort to carry out empirical cross-system comparisons. As described previously, these involved factor analyses including only abilities that were comparable between systems. Subsequently, cross-system congruence coefficients could be computed between factors with loadings on comparable (matched) abilities. Judgmental comparisons across the resultant factor structures produced seven factor matches between the MARS-GWI and ARI-OAI data sets and six matches between the PAQ and each of the other two sets. (One of the original eight judgmental matches between the MARS-GWI and ARI-OAI factors, Auditory Ability, was lost when it failed to emerge after the variable reduction required for comparative analysis.) The resultant matrices of congruence coefficients shown in Table 3 supported the judgmental cross-system matches. With only one exception (Visual Perception, in the comparison of the MARS-GWI with the PAQ), the convergent values in Table 3 are the largest in their respective rows and columns, and even that one disparity does not appear in the mean matrix shown in Table 4. Separate multitrait-multimethod analyses of the four matrices in Tables 3 and 4 confirmed that in all cases the mean convergent (main-diagonal) value was significantly larger than the mean discriminant (off-diagonal) value ($p<.002$). Although not large by conventional standards, under which

factors from the same measures are compared across comparable samples, the convergent congruence values reported here seem substantial in light of (a) their magnitudes relative to the much smaller discriminant values and (b) the likely attenuating effects of cross-system differences in scales, ability definitions, job elements, and raters. Consistent with the rationale underlying multitrait-multimethod analysis, moreover, the cross-system differences make for more conservative comparisons.

These comparative analyses showed encouraging cross-system similarity in the dimensionality of job elements' rated ability requirements. There appear to be six similar factors across all three systems: General Physical Ability, Equipment-Control Sensorimotor Ability, Manual Ability, Reasoning and Problem Solving, Numerical Ability, and Visual Perception. In addition, a Verbal Ability factor emerged in both the MARS-GWI and ARI-OAI analyses; and an Aesthetic Ability factor, though emerging only in the ARI-OAI analysis, is similar to a principal component derived by Marquardt and McCormick (1973) from a comprehensive set of PAQ attribute weights.

The MARS-GWI, ARI-OAI, and PAQ factor solutions accounted for .86, .64, and .84 of their systems' total variance, respectively, compared to mean ability weight reliabilities of .81, .92, and .90 (see Tables 1 and 2). The proportions of total variance explained represent the average proportions of common-factor variance (communalities) in the individual variables, whereas the mean reliabilities represent the average proportions of all systematic variance (common-factor and specific) in the variables (Nunnally, 1978). Thus, the MARS-GWI and PAQ factor solutions appear to account for almost all the reliable variance in their respective variable sets, and the ARI-OAI solution accounts for a substantial part of that variance in its set. As noted, the MARS-GWI reliabilities are lower than those obtained from larger, more homogeneous groups of raters using the behaviorally anchored MARS scales. It is likely that such ratings would contain systematic variance beyond that explained by the factor solution presented here and thus might yield a larger number of factors than shown in Table 2. Nevertheless, the results from this study suggest that, at least within the present context, little

systematic variance would be lost by condensing the individual ability weight vectors to a more manageable number of factors. In addition to imposing parsimony on large sets of interrelated variables, such factors could facilitate cross-system comparison and classification and serve as stable composites for job requirement estimation.

Cluster analyses of the mean discriminant triangles in Tables 3 and 4 was suggested by some moderate sized congruence coefficients between unmatched factors. The solution presented in Table 5 was consistent for all four triangles, with the previously noted exception that the two six-factor triangles did not contain a Verbal Ability factor (see footnote c, Table 5). The solution included two groupings and two isolates, titled as follows: General Sensorimotor Ability, General Cognitive Ability, Numerical Ability, and Visual Perception. Interestingly, three of these titles are similar to the Cognitive, Perceptual, and Psychomotor ability-requirement factors posited by Hunter (1983) based on analysis of test validity coefficients. It should be noted that the cluster solution in this study is merely suggestive of a higher-order classification and does not justify condensation to four ability-requirement dimensions. However, future research should explore the validity of a four-dimensional model and whether it can account for substantial proportions of variance in ability-requirement estimation.

Research currently under way is exploring the factor structure of jobs' ability-requirement estimates, derived by combining their NJD ratings on the PAQ, OAI, and GWI with the previously described NJD ability weight matrices. Preliminary results indicate comparability between factors underlying the job requirement estimates and those underlying the NJD ability weights as reported in this study. It is clear from this preliminary research, however, that the degree of differentiation in the job requirement factor structure depends upon the particular algorithm by which job ratings are combined with NJD ability weights. Further research will explore this question and compare the job-component factors with factors derived from experts' direct global ratings of jobs' ability requirements. Another effort will involve policy capturing analyses in which jobs' direct ability-requirement ratings (as a y variable) are regressed on their NJD ratings or NJD factor scores (as multiple x variables). The resultant regression coefficients

might subsequently serve as ability-requirement weights for the NJDs. Ultimately, multitrait-multimethod comparisons will be carried out on ability-requirement estimates for jobs based on NJD weights derived from judges' ratings (as described in the present study) as well as NJD regression weights based on three different kinds of y variables: (a) experts' direct ability-requirement ratings of jobs, (b) mean ability test scores for representative samples of job incumbents, and (c) test validity coefficients for jobs (Cunningham et al., 1983; McCormick et al., 1972; Sparrow, 1989).

Although the job component approach to attribute-requirement estimation holds considerable promise, more methodological and construct validation research is needed to support it. The large ASVAB test data bank for military jobs could prove useful in such research.

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